

HEMT Technology and Applications in Astrophysics

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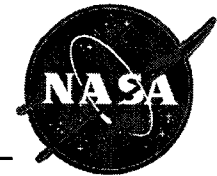
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Overview:

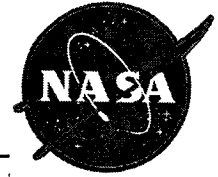
Millimeter-wave transistor amplifiers have many applications in NASA programs:

- Astrophysics: (MAP, Sofia, Planck, FIRST, ARISE, balloon CMB and submillimeter etc. also ARISE, future CMB)
- Earth Observing Systems: Nadir sounding, limb sounding, thermal imaging
- Planetary Atmospheres: water detection, thermal mapping
- Satellite Telecommunications: DSN etc

Significant advances have occurred in *low noise* and *power amplifier* technologies, which have enabled new missions



Low Noise Amplifiers



Low Noise Amplifiers (LNAs) can be used as receiver front ends for systems at operating frequencies as high as 240 GHz. Cryogenic LNAs are competitive with other low noise technologies at frequencies as high as 100 GHz. They play a critical role in IF amplification for SIS heterodyne receivers, with insertion loss multiplying the amplifier noise.

Figures of merit:

$$\Delta T = k T_{\text{sys}} / \sqrt{\beta \tau}$$

ΔT is measurement uncertainty (noise)

T_{sys} is the receiver noise temperature

β is the receiver bandwidth

τ is the integration (observation) time

k is a constant (for gain stability or chop)



Decrease
 T_{sys}, k

Increase
 τ, β (for continuum obs.)



InP HEMT Technology



InP High Electron Mobility Transistors offer the lowest noise, highest operating frequency and lowest power consumption of any millimeter wave transistor:

These advances have been spearheaded by:

- Processing improvements in epitaxial materials
- Short gate lengths using e-beam lithography
- Monolithic millimeter-wave integrated circuit (MMIC) processing advances:

- repeatability
- low parasitics

Disadvantage: MMIC process iteration is slow and expensive